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XXI.—*The Vegetable Individual, in its relation to Species.* By Dr. Alexander Braun, Professor of Botany in the University of Berlin, &c.* Translated by Chas. Francis Stone.

Part I.—Introduction and History†.

In Organic Nature the two principal phænomena, in which the shifting scenes of Life are unfolded, are individual development and individual propagation. Through them the intricate course of Nature, and its living chain of organized beings, are refreshed and renewed. Every new generation seems to bring back the old form; still, to the investigator who looks deeper into the graves of the past, a slow, but certain, progress reveals itself even in this apparently identical succession. If Nature is to be for us something more than a labyrinth of varied and intricate phænomena; and if, in the apparent disorder, the hidden threads of the connexion are to become visible, we must first of all separate and compare the different spheres of life, placing them higher or lower according to their rank. The starting-points which Nature offers for such a purpose are, the *Individual* and the *Species*; whose reciprocal relations, however simple they may at first appear, when followed out to particulars lead to difficulties which demand an accurate examination‡. From the botanist such an

* From the Transactions of the Royal Prussian Academy of Sciences for 1853.—Reprinted from Silliman's American Journal for May 1855.

† I have omitted the author's brief introductory remarks.—*Transl.*

‡ Should any one be inclined to doubt that the nature of the vegetable individual needs a further discussion, I would beg him to turn to the latest works on Botany and compare the passages which treat of the plant's individuality. I take Kützing's Grundzüge der phil. Botanik (2nd Part), as we have a right to demand from a work that lays claim to philosophical

examination is particularly demanded; as the vegetable ideal presented to us by the science in its earlier stages has been obscured by conceptions obtained from the animal kingdom having been transferred to Botany, though based upon the mistaken assumption that plants possess the same independent individuality as animals, the same organs with equally well-defined functions, and the same mutually dependent relations of the vital activities. And the investigations of late years, forsaking the old views more and more, have arrived at no well-defined conclusions, and, particularly as regards vegetable individuality, seem to lead more to negative than to positive results. After all, this should not surprise us; for even a superficial investigation shows relations in plants which will hardly harmonize with the common conceptions of individuality, and which require a careful review.

In the whole realm of organic nature, we know of not a single species of which any one individual is a perfect representative: on the contrary, we see each species adding generation to generation, by multiplying the individuals in time and space, until its day has ended, whether from internal or external causes. In this particular, the species resembles the individual itself; having its allotted age, though measured by days of a higher order, and its appointed cycle of life,—in which the individuals appear as members occupying a certain time and place,—resembling the

development, a fundamental discussion of this subject, since it is the ground-work of the whole science. The first two paragraphs under the heading "Das Pflanzenindividuum als Organismus," read as follows: "By individual we here mean a single vegetable body not organically connected with a similar vegetable body. Vegetable individuals have the power of developing the general phænomena of vegetable life by themselves, unassisted by any other individual of the same species. It is the nature of an organism to consist of members. . . . . The possession of members is the first, as well as the most essential condition of the existence of the vegetable individual." Not one of these assertions is true of vegetable individuals, either in the broader or the narrower signification of the term. To say nothing of the connexion in which the individuals appear which are successively developed by shoot-formation, the coalescence of stocks which were originally separate is no rarity. Are the pines of the pine-forest no individuals, because, as Göppert has shown, they are connected with each other by their roots? Do the filaments of *Zygnema* cease to be individuals when they copulate? Are the cells of *Hydrodictyon* and *Pediastrum*, originally separate, no longer individuals when they have joined themselves into a net or a star? To refute the second assertion, we may refer to dioecious plants; to refute the third, we refer to the one-celled Algæ and Fungi, a part of which, at least, are of such a character that we can by no means ascribe to them an *organization* in the usual acceptation of the term. However, we may regard it as an improvement, that Kützing's 'Grundzüge' treats of the vegetable individual at all; for the earlier manuals do not even mention this important subject, but commence their account of plants with descriptions of the root, stem and other organs, or, as it has been preferred of late years, of the cells and vesicles.

successive relative forms through which the individual passes. For the organic individual does not manifest itself in one single permanent form, but in a succession of forms, now gradually connected, now broadly interrupted; and these last, especially in plants, may attain to an independence which gives them the character of a subordinate species. To this analogy between individuals and species it may be objected, that, in most cases, a very remarkable metamorphosis is connected with the successive forms of the individual, while within the sphere of the species the consecutive members continue to have essentially the same character*. But, however important this fact may be, still we may assert of the individual as well as of the species, that it completes the cycle of its existence in a succession of subordinate generations, while, on the other hand, we may affirm of the species, that, like the individual, it exhibits a determinate cycle of development†. In comparing the processes of propagation with the process of the formation of the individual, cell-formation, which lies at the foundation of both, reveals the intimate connexion which exists between the small and the great spheres of development; while the numerous cases which admit of a double explanation (since they may be ascribed with almost equal justice to the inferior cycle of development of the individual, or to the superior one of the species) establish the close relationship of both. The above-mentioned circumstance, that the cycle of development does not present as graduated a progress in the species as it does in the individual, seems to suggest that the most reliable view of the analogy between the species and the individual is that in which the species is not compared with the whole cycle of the individual's successive development, but with the *single steps* of the metamorphosis (which of course has its own subordinate members), and in which the species itself is regarded as an inferior "momentum" of a still more comprehensive cycle of development; but to determine this would lead us too far from our subject ‡. In a word, the relation of the individual to the species is that of an inferior cycle of development to a superior: the individual is a *member* of the species. However, although they are under one and the same specific law, all the members of the species are not identical: a single member only represents the idea of the species more or less incompletely; and certain members, or series of members, are thus reciprocal

* Those of the forms and properties which persist through the successive generations determine the species. Link, Grundlehren der Kraüterkunde, vi. p. 11.

† The species is an individual of a higher rank (higher power). Link, *l. c.* p. 11.

‡ Cf. the Author's work on Verjüngung (1849), note to p. 344.

complements. The regular relations here brought to view will form the principal subject of the present investigation. But we must first carefully determine the sphere of the individual. The individual shall not and may not be considered by itself: it must be viewed in the successive generations to which it belongs. This succession may be similar or dissimilar, simple or complicated by divisions, continuous or graduated by cyclical changes. It is by this that the phænomena of fissiparous and alternate generation may be explained. It is only by a consideration of these relations that the nature of the individual itself, as a subordinate sphere of the species' development, can be rightly comprehended, and that the single individuals in their worth and importance, in their relations to each other and to the whole realized cycle of the species, can be understood.

Preliminary Remarks on Vegetable Individuality: different views in regard to it.

We must determine what constitutes the vegetable individual, before we can investigate its relations to the whole cycle of generation of the species. But it is this determination itself which presents so many difficulties; and these difficulties become the greater, the further we push our investigations. Individuality in plants seems as obscure and ambiguous, as in animals (at least in their higher orders) it appears clear and simple; so that, as Steinheil remarks, it escapes us just when we are upon the point of seizing it*; and investigators might even conclude that we can realize no other individuality than that which is manifested in the totality of the species. The first obstacle to our comprehending the vegetable individual as a single sphere of conformation, as a morphological whole, is the disconnected and separate character which obtains in the most heterogeneous modifications of vegetable organisms. For nowhere in the vegetable kingdom do we perceive that indissoluble connexion, and those pervading reciprocal functions, which in the animal kingdom we are accustomed to associate with the idea of an individual organism. Nevertheless, by starting from a comparison with animals we get an apposite point of departure for a comprehension of the plant's individuality. Among the higher animals, the individual appears as a member of a race produced by sexual generation; and this very test may be applied to plants, except in the very lowest forms, to which sexual generation does not apply at all,

* "Dans chacun de ces organes nous nous croyons au premier aspect sur le point de saisir l'individualité normale, et partout elle nous échappe." Steinheil, De l'Individualité végétale (1836), p. 9.

or not positively. Without at present discussing the question whether the vegetable individual thus conceived is truly analogous to the animal individual, we may here state, that this conception carried out to its consequences, involves the assumption that all the plant-stocks produced, not by sexual generation, but by any mode of vegetable division, are not individuals, but only parts of the primary individual to which they owe their origin; as Gallesio has in fact contended*. Botanists have often asserted that it is the individual † alone, which is reproduced by slips (branches, buds, tubercles, &c.), and their opinion coincides with this view. Still, how are we to distinguish plant-stocks of such an origin, from those derived from seeds? The former take root, ramify, blossom, ripen their fruit and seeds, just as the latter do, so that in a physiological sense they are complete individuals ‡. For example, let us cast a glance at the weeping-willow (*Salix Babylonica*). It is well known that this tree, which was originally brought from the banks of the Euphrates, is always propagated by slips; for with us it never bears seeds—not because our climate is unfavourable, but because in our gardens there is no fructifying male tree §. According to Lou-

* Gallesio, Teoria della Riproduzione vegetale (1816), a work, which I am sorry to say I have not been able to consult myself. Huxley (upon Animal Individuality, in the Ann. and Mag. of Nat. Hist. June 1852), holding corresponding views, regards all the animals which spring from an egg by non-sexual increase, as *one* individual, or, as he expresses it, as a representative of the individual by successive coexisting separable forms;—regards as such, for example, the sum total of all the *Aphides*, produced in successive generations, by non-sexual increase, from the first "nurse" which sprung from the egg. If we assume with Bonnet that one nurse encloses one hundred young *Aphides* in the tenth generation (and according to Kyber they often reach even a higher number), the series would amount to much more than a billion (1,010,101,010,101,010,101). Those who regard sexual reproduction as the criterion of individuality must admit this as a perfectly legitimate consequence of their view.

† "Gemmæ individuum continuant cum semina speciem propagent." Link, Elem. Phil. Botan. ed. 2. vol. i. p. 332. "Continuant," in antithesis to "propagent," cannot be mistaken. Again, Endlicher and Unger, Grundzüge der Bot. p. 85, say: "In these cases (*i. e.* when the buds drop off) the bud-formation is a true propagation, by which the individual is multiplied; though we must distinguish this mode of propagation from that of generation, by which the species is reproduced." Here the meaning is obvious, though the expression is perfectly paradoxical; for how can we imagine that the individuals are multiplied without the species being reproduced? I have elsewhere attempted to show what is here meant, by representing non-sexual propagation as a propagation *subordinate* to the cycle of sexual reproduction (cf. Verjüngung, pp. 26, 27).

‡ In many cases the experienced gardener can distinguish them, but certainly not in all; in some the difference is very remarkable: *e. g.* in *Araucariæ* raised from branches.

§ This has the advantage of avoiding the disagreeable seed-down. For the same reason, it is said, in China they cultivate the male tree only.

don (Arboret. Brit.), the weeping-willow was sent to England in 1730, by a French merchant named Vernon. It was planted in Twickenham Park, whence it spread rapidly over England and the continent. The tree, from which the first slips that were brought to Europe were taken, was most probably a cultivated one itself, raised from a slip. However this may be, could the descent of all our weeping-willows be traced, it would undoubtedly lead us back to a willow, a female willow, grown in its native country from a seed. And so, on this account, we are to regard all the beautiful weeping-willows of our gardens and our cemeteries—and surely they are perfect trees—not as individual stocks, but as the *disjecta membra* of a primary trunk, now hidden in mythical darkness! In other cases this primary trunk is known with perfect certainty. It can be proved by history that many hybrids and varieties have been produced in one single exemplar; though they now ornament our gardens far and wide, having increased by means of slips, as they do not bear seeds. This was the case of the famous *Cytisus Adami*, which sprung, shortly before the year 1825, from the mingling of *C. purpureus* and *C. Laburnum*. The single parent-stock, preserved in the garden of the celebrated Adam in Paris, has long since disappeared; but its scions and scions' scions have grown up into fine trees in half the gardens of Europe*. In the view just stated, they all form but one individual! To support such a view, its partisans adduce the fact of certain individual particularities being preserved (in dicœcious plants especially the gender), when propagated by slips. In general this is true, and for practical gardening, *e. g.* for the cultivation of the finer kinds of fruit, of the greatest importance; but exceptions are not rare; among which the well-known re-division of *Cytisus Adami* into its two primary stocks is one of the most striking and remarkable. In our gardens the rule is, that from slips the weeping-willow produces female trees; still some exceptions may be noted here. Napoleon's grave in St. Helena is shaded by a weeping-willow, which has become the subject of scientific discussions. It was supposed to belong to a species (*Salix Napoleonis*) indigenous to that island; but Loudon's exhaustive researches show that it is descended from our weeping-willows, one of which was carried from England to St. Helena in 1810. Branches of this *Salix Napoleonis* were brought back to England, and to the astonishment of botanists they bore *male* flowers. Since up to that time no male weeping-willows had been seen in England, a change of gender must have been produced through

* Cf. Verjüngung, pp. 337 and xi. In another place I shall communicate the history of this hybrid, which has since been investigated.

vegetative increase. A similar case has also occurred in Germany. In the Grand-ducal Gardens at Schwetzingen there is a weeping-willow, which, although a descendant from the common parent tree of all European weeping-willows, has changed its gender to such a degree, that we not only find on it the most heterogeneous stages of transition from female flowers to male ones, but on many branches purely male catkins are produced*. Besides these cases, a curled variety of weeping-willow, *Salix crispa* or *S. annularis* of the gardens, is known; which, as it is a mere garden plant, has probably been produced by slip-propagation. If it be true that we sometimes obtain varieties with hanging branches from several kinds of trees by grafting the slips inverted, we should have one of the most remarkable examples of the production of a singular peculiarity by non-sexual increase. But even if such exceptions did not exist, and if in every case a series of peculiarities which are extinguished in seminal propagation were continued by grafting, yet we cannot perceive how we can seriously refuse an individual existence to such stocks as these, produced, it is true, by non-sexual propagation, but still completely separated externally, developing in different places and under the most dissimilar relations, and exhibiting subordinate differences indefinitely, though with certain similar characteristics. But if we were to make any concessions on this point, we should be carried irresistibly on to others.

Most of the modes of non-sexual propagation thus far considered agree in this particular: that some *shoot* of the plant, whether it be undeveloped (eye, bud), or developed (branch, sucker, layer, &c.), is separated from the parent-stock by natural development itself, or by artificial means. As the nature of the separable part is not changed by the separation, it is no great step to attribute individuality to the shoot (or as it is commonly called, the bud), even when it is not separated from the stock. Each single plant-stock could then be no longer regarded as an individual in the usual meaning of the term, but as a united family of individual shoots;—a view which seems to be of high antiquity; as passages are found in Aristotle† and Hippo-

* This tree was first observed by C. Schimper in 1827. Some remarks upon it may be found in Spenner's Flora Friburgensis, vol. iii. p. 1061.

† Cf. Wimmer, Phytologiæ Aristotelicæ Fragmenta, §§ 23–28, 66 et 113. I cannot discover that explicit acknowledgement of the individuality of shoots or buds, which is said by Schultz (Anaphytose, p. 24) to be found in Aristotle, either in Schultz's quotations, or even in Wimmer's complete collection of the passages in Aristotle referring to plants. It is true that Aristotle repeatedly speaks of the divisibility of plants; says that separated parts of plants may continue to exist; that on this account many trees may spring from a single source; that many plants are propagated by slips (*ἀπὸ σπαραγμάτων ἀποφυτευομένων*), and by lateral bud-formation (*τῷ*

crates * which are interpreted in this sense. In later times, this view has been more or less advocated, especially by De la Hire †, Linnæus, Darwin ‡, Batsch, Goethe, Röper, Schleiden §, and others.

But, even in this narrower view of vegetable individuality, the same difficulty meets us; for the shoot itself is divisible, and new stocks may be produced by its parts; *i. e.* by the members of the stem and its leaf or leaf-whorl ‖. Besides, the several members of the shoot are not contemporaneous creations, but, developing successively out of and over each other, they constitute a successive generation, composed of divisions each of which repeats essentially the same form, each of which may be compared to the embryonic plant originally developed in the seed, and consisting of its stemlet with one or two leaves (cotyledons). Thus the shoot itself came to be regarded as a *succession of individual vegetable members*, built up one above the other, like the stories of a house. The earliest traces of this view may be found in Darwin's 'Phytologia' ¶; it was developed at a later period in various ways and with various modifications: *e. g.* by Agardh **,

παραβλαστάνειν), *e. g.* the bulbous plants; but he does not state his opinion of the parts which develope after such a separation, and explains the phænomena in general, by saying that the vegetable soul of plants (θρεπτικὴ ψυχή) is simple in actuality (ἐντελέχειᾳ), though multiple in capacity (δυνάμει).

* According to Moquin-Tandon, Teratologie, p. 5.

† Hist. de l'Acad. Roy. des Sciences, 1708, p. 233. De la Hire regards all the branches as new plants proceeding from hidden ovules. Myriads of these ovules, he thinks, exist between the bark and the wood; more or less of them come to maturity, according to circumstances.

‡ Darwin, Phytologia (1800), p. 1. "If a bud be torn from the branch of a tree, or cut out and planted in the earth . . . .; or if it be inserted into the bark of another tree, it will grow and become a plant in every respect like its parent. This evinces, that every bud of a tree is an individual vegetable being, and the tree therefore is a family or swarm of individual plants . . . ."

§ I shall consider the views of these authors more at large in the next section.

‖ I adduce this point in connexion with the history of the views held by botanists in regard to vegetable individuality, in the terms in which it has been usually expressed; further on I shall show that this view needs qualification. The individual members of the stem cannot expand into a new stock by direct development, like the separated shoot; they have this property only by being connected with a lateral sprout, by means of the eye which they bear, or have the power of producing. This view naturally brings us back to the shoot as the individual.

¶ P. 9; where even the single well-defined stem-members of different herbaceous plants are described as so many buds, and hence as so many individuals.

** Agardh, Essai de réduire la Physiologie végétale à des principes fondamentaux, 1829 (Ann. des Sci. Nat. tom. xvii. p. 86).

Engelmann*, Steinheil† and Gaudichaud‡—the last of whom calls the member of the shoot elevated to the rank of an individual vegetable being, "the phyton," and ascribes to it not only a stem and leaves, but even a root, by which he imagines it is connected with the preceding phytons, as the first phyton (the embryonic plant) is connected with the ground. Steenstrup § and Forbes || employ a similar view for their comparison of alternate generation in plants with that in the lower animals.

But this restriction of vegetable individuality could not stop here; for even the members of the shoot, the "phyta" or "stories," are themselves too complex organisms not to present subordinate divisions, which, like the whole member, possess a certain independence, and under certain circumstances may even give birth to new stocks. Although botanists have attempted to view the petiole as the lower part of the leaf ¶, or *vice versâ*, the leaf as the upper part of the petiole** (so as not to be compelled to divide the phytons of the structure themselves into relatively independent members), this much at least is certain (and it is the important point here), that each of these two parts is capable of producing new growths by itself; yes, this capacity is enjoyed even by different determinate or casual parts of either member. It is well known that the leaf of *Bryophyllum* produces sprouts in every notch on its edges, while on the other hand, caducous leaves of many bulbous plants (*e. g. Eucomis regia* according to Hedwig, *Ornithogalum thyrsoides* according to Turpin††) produce new plants in the form of bulblets on any portion of the whole of the upper surface. The petiole itself under certain circumstances has the power of producing the so-called adventitious buds, not only on the portions determined by the position of the leaf (leaf-axil), but sometimes on any other portions; a power enjoyed by the root in many cases. Hence parts of plants, otherwise most dissimilar, when they contain cambium,

* Engelmann, De Antholysi (1832), p. 12.

† Steinheil, L'Individualité dans le Règne végétale. 1836.

‡ Gaudichaud, Recherches sur l'Organographie, la Physiologie et l'Organogénie des Végétaux. 1841.

§ Steenstrup, On Alternate Generation (1842), p. 128. As this important little work may be supposed to be in every one's hands, I refrain from quoting this interesting passage.

|| Forbes, On the Morphology of the Reproductive System of Sertularian Zoophytes, &c., Ann. and Mag. of Nat. Hist. vol. xiv. (1844), p. 385.

¶ Ernst Mayer, Die Metamorphose der Pflanze und ihre Widersacher. Linnæa, 1832, p. 401.

** Hochstetter, Aufbau der Graspflanze. (Würtemberger Jahreshefte, 1847 and 1848.)

†† Cf. Treviranus, Pflanzenphysiologie, where several examples are adduced.

may have the power of reproducing the plant*. This is the foundation of the *Schultz-Schultzenstein-ian* doctrine of *anaphytons*; viz. those vegetable members "which, even when separated from the plant, continue to live, bud, and develope†," and which are hence regarded as the individuals proper, as the true elementary forms or morphological elements; and it is by various combinations of these that the organs (commonly so-called), root, stalk and leaf, are formed, by the repetition of which the whole plant is built up and indefinitely renewed.

But where are the limits of the anaphytons? How shall lines be drawn to include all the buds of the root, stalk and leaf, from which new formations may spring? Aub. du Petit-Thouars‡, who had already developed doctrines similar to those of the anaphyton-theory, attempts to draw the line between individuals by means of the cellular tissue, regarding every vascular bundle as an individual, since it has in itself, and independently of all others, the means of its growth, its preservation, and the reproduction of new bundles. But it is difficult to perceive how, in such a view, the labyrinth of anastomosing bundles (not less complicated in the majority of petioles than in most reticulated leaves) can be disentangled and resolved into separate individuals, and why the same independence and the same rank should not be allowed to the parts of the vascular bundles. And how shall we regard the lower plants, which have no fibres at all? If our conclusions are to be anything more than mere arbitrary assumptions, we must go still farther; and we shall find no halting-place till we reach *the cell*, the true seat of every renovation in the plant, the starting-point of all non-sexual increase§,

* Aristotle himself says that plants possess the power of reproducing "stalk and root" in every one of their parts (*παντα χῇ γὰρ ἔχει καὶ ρίζαν καὶ καυλὸν δύναμιν*. Vit. long. et brev. c. 6. p. 467).

† Schultz, Die Anaphytose (1848), and System der Morphologie (1847). The passage quoted is taken from his later work, Verjüngung in Pflanzenreich (1851). The remark made above, when treating of the members of the petiole, holds good here. The so-called anaphyta can by no means grow into new plants themselves; on the contrary, the new plant is produced as a germ, which is not identical with the anaphytons.

‡ Essais sur la Végétation considérée dans le développement des bourgeons (1809), cf. *e. g.* p. 174. "C'est donc le bourgeon en qui réside toute l'énergie végétale; aussi le regarde-t-on depuis longtemps comme un individu .... D'après les principes que j'ai développés dans mes précédens mémoires, il faut aller plus loin, car je crois que chaque fibre végétale est un *individu*, puisqu'elle a en soi, indépendamment des autres, les moyens d'accroissement, de conservation et de réproduction."

§ Earlier investigations into the origin of adventitious buds had made it probable that, in its formation, each new shoot arises from a single cell. The first convincing proof of this fact was given by Hofmeister (Vergleichende Untersuchung u. s. w. der Coniferen, p. 94), in *Equisetum*. The propagating cells on the foliage and edges of the leaves of Liverwort, which

as it is of sexual propagation*. The cell has a better right to be considered as the vegetable individual than any other subordinate member of the plant; when connected with other cells it still continues to be an independent sphere of formation, sharply defined and, in youth at least, completely isolated†. Before the universal law of cell-formation was known, and before botanists had succeeded in reducing all the elementary organs of plants to cells, Turpin hit upon the idea of seeking the vegetable individual in the cell; though his views did not rest on as solid a foundation as Schleiden's assertion, that "in a scientific point of view, the cell is the vegetable individual‡."

The most reliable authorities have agreed that new cells can never be formed externally to, but only within, other cells already formed §, so that cell-multiplication must be regarded as a propagation, while all the cells of the mature plant must be regarded as the progeny of the first embryonic cell. Besides, each and every plant is at first a cell; and there are single-celled plants in the strictest sense of the term, in which the first formation of new cells is that destined to reproduction; *i. e.* the germinating cells or spores‖. Again, there are other plants in which the cell-generations contained between the first generation (which sprung from spores) and the last (itself returning into spores) separate from each other, so that all the cells belonging to one cycle of vegetable development are segregated, and live com-

develope into new plants, have long been known. The spores of the Cryptogamia belong here, as they are cells originating and developing non-sexually.

* Pollen-cells, and the embryonic utricle and germinating cells,—as well as those of the archegonium of the higher Cryptogamia.

† Malpighi himself (Anatom. Plant. 1675) calls cells utriculi, or sacculi, though he distinguishes the wood and bast-cells as "*fibræ*," the vascular cells as "*fistulæ*," and the cells containing milky sap as "*vasa specialia*." As early as 1805, Link (Römer's Archiv, iii. p. 439) had expressed himself very explicitly in regard to the isolated position and the independence of cells: "Quævis cellula sistit organon peculiare, nullo hiatu nec poris conspicuis præditum in vicina organa transeuntibus. Conspicies non raro cellulam rubro colore tinctam inter reliquas virides."

‡ Schleiden, Grundzüge, 1te Aufl. 1842, vol. ii. p. 4 [Eng. trans. (1849), p. 127 T.].

§ Cf. Schleiden, Grundzüge, i. p. 267 [Eng. trans. p. 103 T.]: "The process of the propagation of cells, by the formation of new cells in their interior, is a universal law in the vegetable kingdom." Mohl, Anat. und Phys. d. veg. Zelle, 1851, p. 53: "Cell-formation in plants takes place only in the cavities of older cells, not between or upon them." Schacht, Die Pflanzenzelle (1852), p. 47: "The formation of new vegetable cells always takes place in the interior of cells already formed."

‖ E. g., *Ascidium*, *Chytridium*, *Codiolium* (a genus lately discovered in Heligoland), *Sciadium*, *Hydrodictyon* (the last two with "colonial formation").

pletely independent of each other *. The importance of the cell as an individual seems to be decided by these facts; that of the entire plant, as a superior whole composed of individual cells, seems to be settled, and a firm foundation for the doctrine of vegetable individuality to be gained. But let us try to obtain a clearer view of some of the most important of these facts. The view which regards all cell-formation as a process of reproduction rests upon observations of the formation of free daughter-cells, (blastidia) in the contents of the mother-cells (matrices),—the so-called *free*, or *endogenous*, cell-formation. Schleiden, who discovered this process, and Karsten †, the most decided and original of his followers, regarded endogenous formation as the universal law of cell-formation. By this view the whole doctrine was turned in a wrong course, from which it could only be gradually recovered by the discovery, or rather the farther investigation, of another mode of cell-formation, which Nägeli designated as "wandständige," Unger as "merismatic," and Mohl as "cell-formation by division of the primordial utricle." But even at this day the misconception caused by generalizing the view that new cells are formed *within* old ones, has not been entirely removed. I have already ‡ called attention to the fact that cells are divided which have no cell-wall, which is often the case among the Algæ §. In several genera in which numerous spores are formed in one mother-cell, its entire contents first divide into two parts (the so-called daughter-cells), which, without first secreting a cell-wall, immediately divide again into two; and this process may be repeated over and over ‖, according to the number of spores which are to be formed (8, 16, 32, &c.). In the second and subsequent divisions there is no formation of new cells *in* old ones, of daughter-cells *in* mother-cells, and hence no reproduction, in the sense of one or more individuals being produced *in* an old one. The *entire* mother-cell is converted into two filial cells; the filial cells are nothing but the mother-cell divided. And this is essentially the case in every cell-formation by division; for the wall of the mother-cell (within which the division generally takes place) certainly is not the living mother-cell, but

* Many Palmellaceæ, Desmidiaceæ, and Diatomeæ. Cf. Braun, Verjüngung, p. 132 *et seq.*

† H. Karsten (De Cella Vitali, 1843) emphatically rejects every mode of cell-formation by division and by sprouting, and asserts that every cell originates at its first appearance as a dot-like utriculus; regarding all formations found in the contents of the cell as cell-brood.

‡ Cf. Verjüngung, p. 245.

§ E. g., *Protococcus* (*viridis*), *Characium*, *Pediastrum*, *Ulothrix*, *Enteromorpha*, *Ulva*, &c., during the process of spore-formation.

‖ Nägeli (Monocellular Algæ, p. 28) calls such cell-generations "transitory generations."

merely its cast-off garment, its perishing shell. Cell-formation by division (called the "merismatic" or "wandständige") is that which obtains through the whole realm of vegetative development; while free cell-formation occurs only in fructification. Thus, the same phænomenon, which, regarded as endogenous cell-formation, seemed so favourable to the importance of the cell as the vegetable individual, when more justly comprehended only brings us back to the divisibility of the vegetable organism, repeated in the most heterogeneous spheres. But still more: even the cell whose contents are not converted by division into new cells, but remain simple, presents phænomena which can hardly be reconciled with their view by those who regard such a cell as an individual, isolated in space and independent in time. In the genera *Vaucheria*, *Bryopsis*, *Caulerpa*, and other related Algæ in the family of *Siphoniæ*, we find such cases, examples of the most extraordinary kind of cell-formation. The single cell, which forms the vegetable organism of these plants, has in fact a development which may continue indefinitely. Certain parts of the elongated stem-like cell shoot forth into branches which lengthen by an independent terminal growth, without separating from the cavity of the maternal trunk by any partition. The principal trunk of the cell is either creeping, with an indefinite terminal growth, though dying off from behind (*Caulerpa prolifera* *), or it is upright and deciduous, while the sucker-like branches, club-shaped at the ends, and filled with a denser contents, are perennial (*Vaucheria tuberosa*†). In both cases the branches separate from the dying trunk, closing up at the bottom; and thousands of new trunks may thus be produced without any proper cell-formation. Thus the cell leads us back to the point from which we started at the tree; and, as we could not refuse individuality to the ramifications of the tree, neither can we refuse it to the ramifications of the cell. Hence we cannot regard the cell as an absolutely single being, completely isolated and indivisible. Shall we penetrate still further into the anatomy of the cell itself, in the hope of possibly finding a valid vegetable individual? All that we discover here is, first, the vesicles, spherules and granules in the contents of the cell (amylum, chlorophyll and other pigment-vesicles, spherules of fat, and, finally, the granules of the viscous cell-contents, whose chemical nature it is difficult to determine); and secondly, the

* Cf. Nägeli's important paper on this plant (Zeitschrift für wissen. Bot. i. p. 134), especially the exposition of the above-mentioned relations beginning p. 158.

† A new species from the vicinity of Lake Neuenberg in Switzerland, remarkable for its purely furcated ramifications, with constrictions at the bottom of the branches, as well as for the club-shaped suckers at the ends.

fibres, which compose the cell-membrane according to the old view advanced by Grew and lately revived by Meyen * and J. Agardh †. These parts, it is true, have often been regarded as the elementary forms ‡ of plants, or their primary "individualized" bodies §; the attempts, however, to represent them as the true and real vegetable individuals are not numerous; and they astonish us by their daring rather than entice to imitation. Turpin, who commenced by considering plants to be composed of different kinds of individual cells, which he compared with various lower plants (especially the Algæ-genera *Protococcus* and *Conferva*), afterwards expanded his views, so as to regard the cells themselves as individuals of a second rank; while he considered the true primary individuals to be the granules of the cell-contents, from which, in his opinion, the cell (cell-wall) is formed by agglomeration ||. Mayer of Bonn, basing his theory upon molecular motions, considers the smallest granules of the cell-contents as individuals possessing animal life (biospheres), which build up plants for their dwellings. "Like hamadryads these sensitive monads inhabit the secret halls of the bark-palaces we

* Meyen, Pflanzenphysiol. i. p. 45; answered by Mohl, in his Vermischte Schriften, p. 314.

† J. Agardh, De Cell. Veg. fibrillis tenuissimis contexta (1852). Notwithstanding the importance of the author's new investigations, they still need a more searching examination, as some points directly contradict well-ascertained facts, *e. g.* the direct transition of the fibres from the outer to the inner layers of the cell-wall. The whole theory of the formation of cells by the uninterrupted growth of fibres cannot be admitted in view of the undoubted independence of the formation of the cell-wall from the contents. Mohl is certainly right in regarding the fibrous division and divisibility of many cellular tissues as a mere structural relation of the membrane (which in other parts is continuous); and he thinks it depends upon the peculiar mode of agglomeration of the molecules. As such molecules of the cell-wall are invisible, I think it preferable to regard it as dependent upon a regular change of the relations of density.

‡ Kützing, Phil. Bot. i. p. 125, 129, does not regard the cell as the elementary form of plants, but as a complicated structure itself, and preceded by many other more simple forms, which he comprehends under the name of "molecular tissue," and which, he says, present in themselves many lower vegetable forms;—plants which are not even cells!

§ Unger, Grundz. d. Anat. u. Phys. der Pflanzen, p. 4. The cell is represented as the "elementary vegetable organ;" but the vesicles, fibres and granules within it are further distinguished as very minute, "individualized" bodies.

|| Turpin, "Sur le nombre deux" (Mém. du Musée, xvi. 1827, p. 305): "Ainsi des individus globuleux, rapprochés simplement contigus, forment la membrane de la vésicule Individu du tissu cellulaire, le filament Individu du tissu tigellulaire, et la membrane cuticulaire Individu. Des agglomérations de ces derniers constituent les Individualités, provenantes des bourgeons développés, et enfin, celles-ci achèvent *l'Individualité composée* d'un arbre."

call plants, and here silently hold their dances and celebrate their orgies *."

Farther than this we cannot go: if we did, we should have to leave *specific* vegetable life, and, instead of investigating its most minute spheres of formation, the visible cells, vesicles, granules or monads, turn to the invisible *individua* † of brute matter, so as to consider plants as phænomena of appellant and repellant, coherent and incoherent atoms. If we must understand by an individual, a being perfectly simple and indivisible, this is our last refuge, in which we may indeed reach an individual, but not a *vegetable* individual; for this would then be identical with the material individual common to all corporeal existence. But, even if we could give up all hopes of a specific vegetable individual, doubt would still linger round these physical individuals; for even the existence of the universal primary particles of bodies—the material individuals, the atoms,—is not conclusively established. No eye has seen them; we do not even think of considering them as objects of direct perception; we only accept them as an hypothesis, to eke out our theories of motion and of chemical affinity; and to enable us to compute their relations. The question might easily be asked, whether the same phænomena may not be as well explained by assuming the continuity, expansibility, and penetrability of matter. However this may be, the question concerning the existence of atoms certainly lies beyond the limits of botanical investigation; and if the existence of vegetable individuals depends on this question, the botanist must despair of proving it. Thus the question at which we have now arrived is this: can we speak of individuals in botany? and this is identical with another: are plants mere products of the operations of matter (*i. e.* of a substance self-moving, uniting and separating by an innate force), and hence non-entities, or mere phænomena resulting from, or produced by, the blind forces of nature; or may we ascribe to plants an independent existence in nature, notwithstanding their connexion with the external world?

If what we call plants are nothing but complex chemical and physical *processes*, then we can no longer speak of their individuals and species in the sense the words usually bear; for the mere phænomena of the operations of the primary substance, which have no other efficient principle than the forces of this substance, cannot be regarded as self-existent beings, or as peculiar (specific) kinds of these beings, or as single (individual) modifications of them. This is, in fact, the result towards which the

* Mayer, Supplemente zum Lehre vom Kreislauf (1837), p. 49. I am acquainted with Mayer's views through Meyen's Pflanzenphys. ii. p. 256.

† Cicero calls the atoms "individua."

later physiological investigations are hastening, grounded on the positive results of investigations in the physical sciences. Even vegetable physiology cannot resist this tendency of science, although it struggles more or less against these conclusions *. The operations by which plants, and all organic beings, form and preserve their organisms, were formerly ascribed to peculiar vital forces; but the physiology of our day would recognize in the vital functions of the organism the same forces by which the processes of inorganic nature are performed. Thus physiology becomes physics and chemistry, or, according to the usual conception of the physical and chemical processes themselves, the "mechanics" of organic nature in the most comprehensive meaning of the term mechanics. And thus the life of the enchanter is unveiled, who had seemed to be the immediate cause of his own works; the lofty partition-wall between organic and inorganic nature falls, and one common foundation is laid for investigating all material processes in every realm of nature. This important result is reached: the existence of the higher orders of natural phænomena, which had been regarded as the peculiar realm of Life, is referred to the same natural causes (the same material substance and the same kind of forces) by which the lower orders, those of "inanimate" nature, have their being and perform their functions. Still further conclusions may be attempted, and it is in the nature of scientific progress that these attempts should be made. As physical forces seem to be everywhere indissolubly connected with matter, and as a fixed regularity displays itself in their operations, men were found bold enough to consider the totality of natural phænomena as the result of original primary substances, cooperating with determinate forces, according to the laws of a blind necessity;—a natural mechanism revolving in its endless orbit †.

Though this view seems to explain all the phænomena of nature from one principle, in fact it precludes any real explanation

* Even Schleiden, the most prominent and most decided of the representatives of this tendency, seeks to counterbalance the deadening effects of the purely materialistic view by an æsthetic one (Die Pflanze und ihr Leben; last lecture, D. Æsthetik der Pflanzenwelt).

† As far as concerns natural history these views are developed, *e. g.* in both of Mohlschott's works, D. Physiol. des Stoffwechsels in Pflanzen u. Thieren (1851), and D. Kreislauf des Lebens (1852); in the last-mentioned work we find such sentences as these: "The miracle of nature is the interchange of matter, the first cause of physical life," p. 83. "Creative omnipotence means the relations of matter," p. 258. "The hinge round which the wisdom of the present day is turning is the doctrine of the interchanges of matter," p. 363.—The doctrine, that the universe is the play of attrahent and repellant atoms, belongs, after all, to the "wisdom" of the past, professed by Democritus and Epicurus.

of them, that is, when exclusively applied to their solution. That which is eternally necessary can only be conceived as eternally carried out; and thus any real event becomes an absurdity. If the "mechanical" (physical and chemical) forces of nature are necessarily active, then if any motion is to take place, the first impulse, the proximate cause, cannot be explained by the nature of the motion; it must be another principle above necessity; and this is true not only of nature as a whole, but also of every particular motion in nature as well. Thus not only the first impulse, but the universally apparent final cause, remains an inexplicable riddle in the doctrine of blind necessity. Hence the insufficiency of the "physical" theory, compared with the "teleological*," is peculiarly obvious in the realms of organic nature, where the final cause of each particular life appears so distinctly. The advocates of the physical view perceive this; but they explain the fitness of means to ends in nature as a whole, and in its individual parts, by supposing matter, with its blind forces, to have been created by an intelligent Being†. But we can regard this as a germ of an explanation only in proportion as it is also granted, that the intellect of the Creator lies not only behind and without nature and her processes of development, but that, as if incorporated in nature, it is taken into the destiny of each created being, in proportion to its individuality. But this again presupposes the admission of a substantiality of nature fit for such an hypothesis;—a substantiality not grounded on mere matter, like a blind force; but which, on the contrary, must comprehend matter as subordinate to itself, and must realize itself through matter:—an assumption which modifies the physical view essentially, and would seem to be a modification of some ideal, or teleological theory.

Without underrating the great importance which the physical view possesses for vegetable physiology, still we must confess that we cannot find in it the key to a conception of vegetable individuality; for, after all, this must be sought for, not in the external conformation, but in the essence of the plant, determined

* Cf. Schwann, Microscopische Untersuchungen über die Uebereinstimmung in der Structur u. d. Wachsthum d. Thiere u. Pflanzen (1839), especially p. 221–225; on the other side, Eschricht, D. Physische Leben (1852), in sections ii. and iii.

† "The fitness of means to ends, in every organism, even a superior degree of this individual fitness, cannot be denied; but in this (the physical) view, the cause of the fitness does not consist in the fact that every organism is produced by an individual force tending towards a certain end, but, like the cause of the fitness of means to ends in the organic world, that matter is the creation of an intelligent Being." Schwann, *l. c.* p. 221, and, in almost the same words, p. 224.

from within. This leads us from the last negative results to an historical view of the attempts at a positive explanation.

It is evident from the foregoing review that, if we would not give up all hope of conceiving plants as *beings, realized in individual conformations,* we must not allow so great and decisive an importance to the external divisibility of their organism as has been usually done. We must seek a decision in the essential concatenation of all the steps in the plant's development forming one whole, according to one idea. This is the tendency of the concluding remark of Nägeli, to which he is led by the relations of growth and propagation in *Caulerpa,* when he says, that indivisibility of form is not an element essential to individuality—which, indeed, must be constructed upon a new, and somewhat less material basis. Link calls attention to this same unity, which is expressed in the whole development of the plant, and which forms the essence of its individuality, in the following true words: "We cannot recognize an individual unless we are convinced that it remains the same in different periods of its existence *." Now the question is just this: how can we perceive such a oneness of essence amid these changes of form and material? How do we perceive that, with all its divisibility, the plant remains after all really one and the same individual?

Every development presents a succession of phænomena, which, while they present themselves in a regular order, also show unmistakeably a point of departure, an end, and a course between the two advancing after a fixed plan, and which indicate a common internal principle †. They point to an internal vital principle ‡ common to the whole succession;—to a principle which

* Link, Elem. Phil. Bot. ed. 2. p. 11.

† Du Petit-Thouars, *l. c.* p. 284: "L'individu est un être dont toutes les parties sont subordonnées à un principe unique d'existence." Link, Elem. Phil. Bot. ed. 2. p. 3: "Nos individuum vocamus, quod ab uno eodemque principio interno determinatum est, ad idealem potius quam ad realem respicientes divisionem."

‡ Spring, Ueber d. Begriffe v. Gattung, Art u. Abart (1838), p. 55. "It is this indwelling principle which makes the individual; and in natural history, every body is an individual in as far as it really exists as a single being, whose existence is determined by a peculiar indwelling vital principle." Spring afterwards distinguishes the *systematical* and the *physiological* individual: in the former one phase of the development is comprehended, in the latter the whole metamorphosis. The physiological individual comprehends an assemblage of forms, which might be regarded by a casual observer as so many systematical individuals. Still, a true systematist must protest against such a purely subjective distinction of systematical and physiological individuals. However much the embryos of Mosses resemble Confervæ, or the larva of an insect resembles a worm, a true systematist will not separate the young individual from the developed

must be conceived of, not only as an idea which guides the whole process, or as a force determining the specific type of this plastic succession, but also as a living essence, comprehending the idea as its internal determination, and the force as the means of its realization;—an essence which precedes and shapes the external existence; as intentions precede and determine acts*. If, in ac-

one; and genera which are founded upon our ignorance of their successive development, as *Protonema*, *Lepra*, *Sclerotium*, &c., must be given up by the systematist himself. True, we shall be called upon at a later point in this inquiry to decide, whether a sphere of development which really belongs to the individual can present itself to us so divided that the divisions themselves attain to the importance of subordinate individuals.

* Aristotle describes the internal essence of plants as a "plastic soul" (*θρεπτικὴ ψυχὴ, τοῦ ζῶντος σώματος αἰτία καὶ ἀρχή*). Cf. Wimmer, Phytol. Arist. Frag. c. iii. De Pl. Vita atque Anima. The charge of anthropomorphism has been made against such a view, which attempts to conceive of nature as a chain of essences, both in the reciprocal relations of her forces, and in her internal developments; but, if man himself is a member of nature, if he is the highest member in the order of natural beings, that member which presents the most complete unison of all the phases of life in nature, —then all his knowledge of nature must be connected with his knowledge of himself. However meanly we may estimate this knowledge at the present stage of psychological science, still it is sufficient to assure man of his own "ego." And if man is justified in regarding himself as a human being, by analogy he is justified in regarding his relations, the animals, in the same manner, as animal beings; plants as vegetable beings; and every single animal, every single plant, as an individual being (even though included in a higher entity). To attain a unity of idea in Natural History, man must apply this idea farther down in the scale of nature, and must regard minerals, even the elements themselves, as beings of their own kind. But the materialist will reply, Individual beings are only the elementary substance: all other beings, so called, are formed by a temporary composition and cooperation of these. But who has seen these elements of chemical combinations, as *elements*, or has proved their existence in any way? But even if they should exist as such, is it not conceivable that a higher being should include the lower beings? We say, hydrogen and oxygen form water; but it would do as well to say, water forms itself out of hydrogen and oxygen. The elements do not form the plant; the plant forms its body out of the elements. We may declare both these views to be hypotheses; but of hypotheses that is preferable which is nearest to man,—I would almost say, most necessary to man's nature, when he proceeds from the data of his own existence. Shall the elements have a stronger claim to be acknowledged as real existences than man himself? Or will any one say that it is a more daring hypothesis to assume that man thinks; that brutes move themselves; that plants themselves produce the determinate form of their organism, than to suppose that elementary substances in their connexions and cooperations produce the phænomena of thought, voluntary motion, and typical conformation? But after all, is it not true that the elementary substance is everywhere present? that without it none of the phænomena just mentioned can occur? Certainly this is so; the higher stages cannot be realized without the lower, which enable them to exist; but these higher stages can never be explained by, and comprehended in, the lower. No one, as yet, has shown even the shadow of a possibility of explaining, from the things themselves merely, why the ele-

cordance with this idea, we regard external development as the revelation of the internal essence, which exhibits its purport in the processes it undergoes in connexion with the world without it, and whose realization is thus produced by a determinate sphere of activities, necessary for such a realization, then, *vice versâ*, we may infer the essential unity of each particular sphere of development from the complete unity of the functions relating to this realization. This leads us to the attempts made at a physiological determination of the vegetable individual. The usual definition, and one entirely in accordance with the physiological point of view, is that an individual is a perfect representative of the character of the species, possessing all the functions necessary to the continuance of the species. Now if we would conceive of a physiological individual, in the broadest meaning of the term, we should certainly be compelled to demand that our conception should be such as to exhibit not only single phases, but all the phases of the specific life during its entire development; that it should realize all the capabilities of the specific being, and thus present to us the whole plan, the whole destiny of the species. If we examine the preceding conclusions from this point of view, it will be evident that single cells cannot be such individuals; for, although the whole construction of the plant and all the functions of its life are carried on by means of the cells, still, viewed as a connected whole, the cells are only single stones, single elements, in the great mechanism of the

mentary particles form a mineral kingdom, a vegetable kingdom, an animal kingdom, and man. And why do they not fulfil their task after an eternal, immutable manner, since such a fulfilment is one of their necessary, eternal, and immutable properties? Why have they succeeded in composing man only in the most recent geological epoch? Why have they not from eternity produced in man's brain the theory of their actions, and thus, in accordance with their eternity, eternally manifested and glorified themselves? The most industrious investigations into the relations of the physical world promise us a deeper insight into the regular connexions of all the parts of nature; into the cunning mechanism which carries on and upholds all natural life. Still, a key to the interior of this structure, and an admission to the essence of plastic nature in her operations, cannot be found by our investigations, if, by presumptuous hypotheses, they debar us from the higher realms of development, especially those of organic nature and of human life. Flesh and blood are hypotheses; but mind is truth, says a well-known writer; and Des Cartes could find a proof of his own existence and of that of the world around him in his mind alone. It would be a strange contradiction, if the investigation of the most distant realms into which the human mind can penetrate should rob us of what is nearest and surest, the intellectual *ego* itself, the starting-point of all investigations. But he who has not recognized the foundations of the spiritual world in nature itself, must of consequence deny their existence in man, if he would not lose, in an inexplicable dualism, the hope of obtaining coherent views of nature.

organism. Any single member of a plant (as the internode and leaf) corresponds no more to such a physiological individual than does the cell; for plants undergo their metamorphoses in their successive members; and the various processes of their preservation, reproduction and propagation are connected with the various steps of these metamorphoses. Nor can it be the shoot; for that usually does not embrace all the steps of the metamorphosis; besides, the functions are variously distributed in the shoot; and in many cases, this takes place for the reciprocal completion of the functions. Besides, whatever is characteristic in ramification and in growth depends upon the combined shoots, and without these it is impossible to conceive of trees, for instance. Then we come back to the whole plant-stock! Nay, farther; we cannot stop at the plant-stock; for the single stocks are far from being perfect representatives of all the phases and tendencies of the specific life. I would refer to the division according to gender, or the modes of fructification, which is often made in botany; the dicœcious and tricœcious * relations, and farther, to the varieties, especially to those which do not possess essential organs and functions, which belong to the species as such; *e. g.* those varieties which never bear blossoms (ball-acacias), or which never produce fruit (congested blossoms), or which never perfect seeds (currant-grape, cultivated bananas and bread-fruit trees). Besides, no stock is exactly similar to another: we ascertain only the limits of the possible relations of the specific form by a comparison of many stocks. As in animal physiology the solution of the problem of the life of many animals depends upon their social relations (societies composed of couples or of flocks, or of self-governing states), so in vegetable physiology it depends upon characteristic physiological traits whether plants live singly and dispersed, or in societies. For example, in considering the life of turf-mosses, we must determine whether they grow in great sods or in carpets; and of grasses, whether they form meadows; or of trees, forests. Even the relations of geographical distribution, which are discovered by a comparison of all the stocks, depend upon the physiological character of the plants: plants of sensitive and inflexible constitutions are found only within narrow limits; while plants of adaptive and pliant constitutions are more widely distributed, become migratory plants, and by degrees spread over almost all parts of the earth, if their seeds possess the necessary properties.

* Tricœcious plants are exceedingly rare among Phanerogamia (*Ceratonia*, some kinds of *Rhus*), but are more common among the Cryptogamiæ; perhaps we may add the Floridie. In *Polysiphonia violacea* I have found three kinds of stocks mixed, and in the same stage of development in the same place (upon the same thread in *Chorda Filum*).

From these considerations, and many others which might be adduced, it is obvious that there are no determinate limits to a purely physiological conception of the vegetable individual; and that we may expand the definition of the individual until it coincides with that of the species itself.

How then can we steer a middle course, between the morphological view, which results in indefinite subdivision, and the physiological, which ends in indefinite expansion? The physiological view has shown that none of the divisions or spheres of formation, which have been regarded as the individual ones, fully realizes the idea of the species; and that each needs the others to render this idea complete. The morphological view has shown, in the same manner, that there are subordinate and comprehensive spheres of development, none of which exhibits complete independence, since all appear in unequal degrees, as more or less perfect members of the entire succession of the specific development. If we would discover the individual under such circumstances, we must not demand of it all that belongs to the species; for this is *completely* represented only in the totality of the individuals, not in any single individual. We must answer this question: Which member of the graduated potential series in the sphere of development subordinate to that of the species deserves *pre-eminently* the title of individual? And we shall be compelled to reply: That which exhibits the most complete independence and definiteness. Good use has decided in regard to man (and the higher animals), and it justifies itself by the fact, that what is usually termed an individual undoubtedly possesses great organic independence: and this is true both of its subordinate spheres (*i. e.* the members of the organism, down to the cells) and of those by which the individual is comprehended (family, state, race, &c.). By means of comparison and analogy, the signification of the more doubtful spheres of development among the lower animals and plants may receive some new light from such a view. I propose to attempt this in the second part of this investigation, but now I will only subjoin a few general remarks.

In the conception of individuality, there are two elements; that of multiplicity and that of unity. Each development exhibits multiplicity; but this multiplicity is not equally subordinate to the unity in every development. The more complete this subordination, the more perfect is the individuality; for it is only this subordination to the unity which binds up the multiplicity of the conformation into an indivisible organism. The less complete the subordination, the more perfect will be the independence of the parts, and the more indefinite will be the individuality of the whole. If we apply this view to plants, whatever

is dubious in our conception of vegetable individuality will be explained. Successive development, we may say, is the peculiar nature of plants, which, beyond the power exhibited in the process of formation and propagation, possess no higher vital power; while in animals the process of the formation of the body appears only as an operation preparatory to its connexion with a higher vital activity. For animals, in addition to their powers of external manifestations, have a power of internal vital comprehension, which expresses itself in the life of the soul (by which animals possess an internal centre, from which the organism is governed and regulated). It is the soul alone which connects in indivisible unity, and for reciprocal services, the products of the plastic power, and gives to the organism of animals the character of a definite individuality. Among plants the case is different: plants in their operations are active solely in one direction, externally—are split up, so to say, in the process of external conformation, so that the parts appear less connected, as compared with the plant as a whole more independent, and more divisible among themselves. Thus the vegetable organism is a *dividual*, rather than an individual; a multiplicity * rather than a unity; *i. e.* a whole whose parts hold the same relation to each other as individuals to each other, but which present spheres as indivisible as the whole itself. This is the doctrine of the *relative* † individuality of plants, which Steinheil has especially noticed. According to this doctrine, different orders of vegetable individuals, as it were different powers of individuality, are distinguished. In the same manner DeCandolle ‡ distinguishes the cell-individual (*l'individu cellulaire*, in which he has been preceded by Turpin); the bud-individual (*l'individu bourgeon*, after Darwin); the slip-individual (*l'individu bouture*); the stock-individual, or the vegetable individual (*l'individu végétal* penes quem est jus et norma loquendi); and the embryo-individual (*l'individu embryon*), which, in accordance with the

* "Planta est multitudo." Engelmann, De Antholysi, p. 12.

† Steinheil, *l. c.*, especially p. 4 and p. 17: "Les végétaux ne peuvent arriver à l'individualité absolue; ils se présentent à nous dans un état, qu'on peut désigner par le nom d'individualité relative; ce qui distingue cette partie de la création du règne minéral, où l'individualité est nulle, et du règne animal, où elle est presque toujours absolue."

‡ DeCandolle, Physiologie Végét. p. 957. The author does not attach much importance to his division, as he says he has assumed it for convenience of expression, and to avoid the usual confusion of language. His son Alphonse DeCandolle considers it quite an arbitrary matter which part of the plant we call the individual: "Les végétaux sont évidemment des êtres composés: mais jusqu'où veut-on les décomposer, pour que les élémens s'appellent des individus? C'est une chose arbitraire, qui dépend de l'idée par laquelle on se laisse dominer" (after Steinheil, p. 6).

meaning in which Gallesio used the term, comprehends all that proceeds from one germ, even if multiplied by division. Since the slip-individual is essentially the same as the bud-individual (*i. e.* shoot-individual), we have four degrees of individuality, in which at least one more might have been easily inserted, between the cell and the shoot-individual), *i. e.* the member or "story"-individual (Gaudichaud's *phyton*). With this view Schleiden's division is connected: he distinguishes the cell as the plant of the first order; the shoot as that of the second, which he calls the *simple* plant (a term borrowed from C. F. Wolf, who used it in the same sense); the whole stock as that of the third order, which he designates as the *composite* plant. By a searching investigation into the shoot, I shall endeavour to decide whether all these relative individuals can be considered *individuals* with the same justice; or whether, after all, one of them does not deserve the title pre-eminently, corresponding to the animal individual. In either case Goethe's words may be applied with perfect justice to plants and their individuality:—

> Freuet euch des wahren Scheins,
> Euch des ernsten Spieles;
> *Kein Lebendiges ist Eins*
> *Immer ist's ein Vieles.*

Herder, in speaking of the works of the Creator, says: "Every one of Thy works Thou makest *one* and perfect, and like itself alone."

This sentence presents the other aspect of existence, by which the multiform is one; and every unity in the one-sidedness and incompleteness of all single manifestations, is after all a perfect whole. These words lead us to the internal essence of things, referring us at the same time to the primary ideas, which Nature comprehends and realizes in Life.

[To be continued.]

XXII.—*Note on the Subgenus* Limea, *Bronn.*

By John Lycett, Esq.*

The present note is intended to direct attention to a peculiarity connected with the external surface of *Limea*, trivial in its zoological importance, but which is calculated from its persistency to be a useful aid to the palæontologist in the absence of hinge characters.

* Read to the Cotteswold Naturalists' Club, August 28th, 1855.